



European Strategy and CERN Neutrino Platform

Francesco LANNI (CERN)

P5 Town Hall at Fermilab - 21-22.03.2023

European Strategy Update (2013)

- CDS Doc. [CERN-Council-S/106](#)
- **High-priority large-scale scientific activities**
 - ✦ Four activities identified as carrying the highest priorities: (i) *full exploitation of LHC...*, (ii) *design studies for accelerator projects in a global context...*, (iii) *possible participation of Europe to a proposal from Japan for an electron-positron collider...* (iv) *neutrinos..*
 - ✦ Rapid progress in neutrino oscillation physics, with significant European involvement, has established a strong scientific case for a long-baseline neutrino programme exploring CP violation and the mass hierarchy in the neutrino sector.
 - ✦ **CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan.**
 - ➡ *Note that in the 2013 ES update document both the US and Japan LBN projects are recommended on an equal footing*


Neutrino Platform

- Neutrino Platform project created in Sep. 2013
- Original Mandate:
 - ✦ Support the European Neutrino Community in their R&D (detectors and components) in the short and medium term
 - ✦ Provide to the ν community a test beam infrastructure
 - ✦ Bring R&D at the level of technology demonstrators in view of major construction activities
 - ✦ Support the short and long baseline activities (infrastructure & detectors)
- ➔ ***In the Jun 2014 APPEC Paris meeting dedicated to Large Neutrino Infrastructures, CERN confirmed that all types of Neutrino beams at CERN (for Short and Long Baseline) will not further pursued in favor of common activities in US and Japan involving European partners***

DC/2013/263

12 September 2013

MEMORANDUM

To : S. BERTOLUCCI, S. LETTOW, S. MYERS
From : R. HEUER 
cc : M. NESSI
Subject : CERN Neutrino Project

Following the events of the last few months and in line with the approved European Strategy, an initial project is starting at CERN, with the aim to provide an effective platform for future neutrino research activities at CERN and/or outside CERN.

The proposal SPSC-P-347 (ICARUS-NESSiE) and the expression of interest SPSC-E-007 (LAGUNA) have been conditionally approved by the August 2013 CERN Research Board with the CERN code WA104 and WA105 respectively. Conditionally implies that at this moment in time the construction of a short-baseline neutrino beam is not granted and the focus is mainly on detector technology development and qualification in test beams.

The initial LOI for a CERN neutrino facility should proceed towards concluding the detailed studies in early 2014, to allow a timely implementation, in case a positive decision would be taken in this direction.

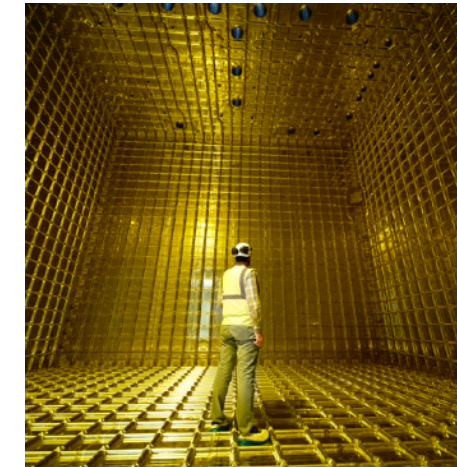
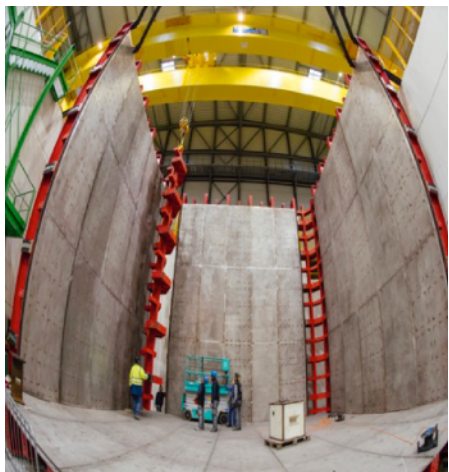
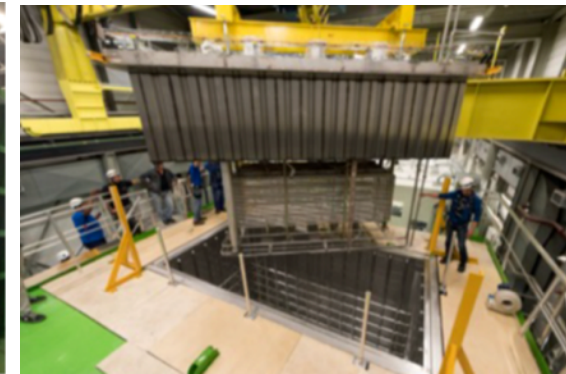
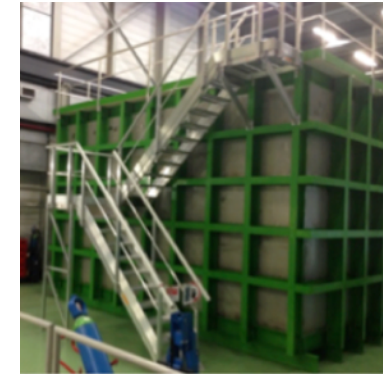
The on going discussions and R&D plans with the US and the Japanese Colleagues should continue, in view of presenting to the CERN management a plan towards a major Intensity Frontier Facility, according to the European Strategy decision.

A CERN project is now created with the aim to foster collaboration with all partners mentioned above and to create an effective research platform, supported by CERN, for a future neutrino research activity involving European partners.

The above-mentioned CERN project will be coordinated Marzio Nessi, as CERN project coordinator who reports directly to the CERN Directorate.

Neutrino Platform (cont.)

- In 2015 CERN Council approved an important amount of resources for the Neutrino Platform as part of the Mid Term Plan
- Construction of the ENH1-1 extension (2016), assembly areas and R&D labs.
- First (WA105) Dual Phase demonstrator (2016)
- Construction (2016-2017) of the NP02/NP04 large cryostats w/ membrane technology (~750 tons)



Neutrino Platform (cont.)

- 7 Experiments approved by the SPS Committee:
 - ♦ **NP01:** WA104, SBND, ICARUS for the US/FNAL SBN (completed 2017)
 - ♦ **NP02:** ProtoDUNE WA105, demonstrator/engineering prototype initially for a double phase TPC - now Vertical Drift (ongoing)
 - ♦ **NP03:** PLAFOND a generic detector R&D framework for accelerator-based neutrino experiments (ongoing)
 - ♦ **NP04:** ProtoDUNE for single phase (Horizontal Drift) engineering prototype (ongoing)
 - ♦ **NP05:** Baby Mind, a muon spectrometer for the WAGASCI experiment at T2K (completed 2017)
 - ♦ **NP06:** Enhance Neutrino Beam from kaon tagging (ENUBET)
 - ♦ **NP07:** Contributions to the T2K near detector - expected completion by end of the year
- 1 additional to be processed and agreement to be defined:
 - ♦ **HyperK:** lab-space for production testing and limited support for procurement of electronics components (experiment submitted proposal to become a CERN recognized experiment)

Neutrino Platform (cont.)

- Advances on LAr TPC detector technology for DUNE (2018-2022):

- Finalized APA's configuration and components for the Horizontal Drift

- Testbeam Sep-Nov 2018
- Cosmic runs (Sep 2018 - Jul 2020)
- Study of detector performance within or above specifications (signal-to-noise, stability and reliability of the cold electronics)
- Studied Xe doping (spring/summer 2020)
- Achieved LAr Purity level above 20 ms lifetime
- HV and drift field stability for Horizontal (-180 kV over 3.6 m) and Vertical (-300 kV over 6 m) Drifts ProtoDUNEs (until Mar 2022)

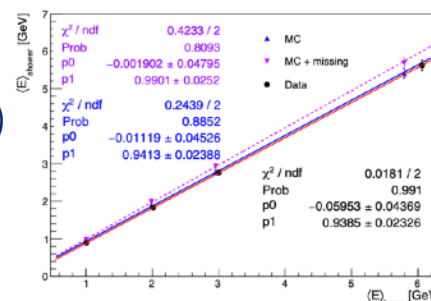
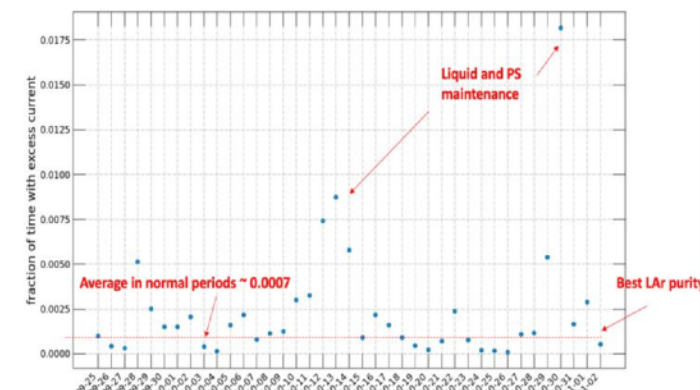
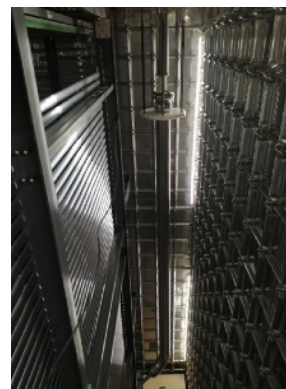
- Trigger and readout

- Development of large scale optical readout (ARIADNE)

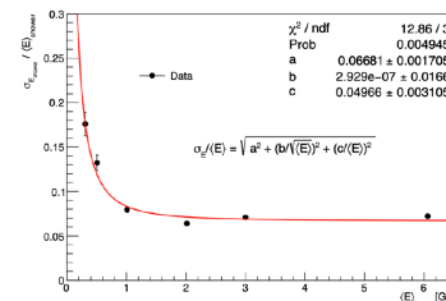
- Reconstruction and analyses:

- Energy reconstruction of electrons
- Hadron-LAr cross-section measurements

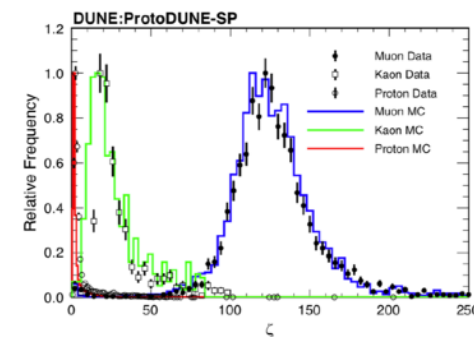
Detector Parameter	Specification	Goal	ProtoDUNE Performance
Electric Drift Field	> 250 V/cm	500 V/cm	500 V/cm *
Electron Lifetime	> 3 ms	10 ms	> ~30 ms in TPC **
Impurity Concentration	(<100 ppt [O ₂ -equiv])	(<30 ppt [O ₂ -equiv])	< 10 ppt
TPC Electronics Noise	< 1000 e ENC	ALARA	550-650 e ENC (raw) 450-560 e ENC (cnr)***
TPC dead channels	< 1%	ALARA	0.2 % (of ~15,360 channels over 1.5 yr operation)
PhotoDetector Light Yield	> 0.5 Ph/MeV (at cathode plane - 3.6 m distance)		1.9 Ph/MeV ** (at 3.3 m distance)
PhotoDetector Time Resolution	< 1μs	< 100 ns	14 ns ^^



Reconstructed beam electron energy linearity



Reconstructed beam electron energy resolution

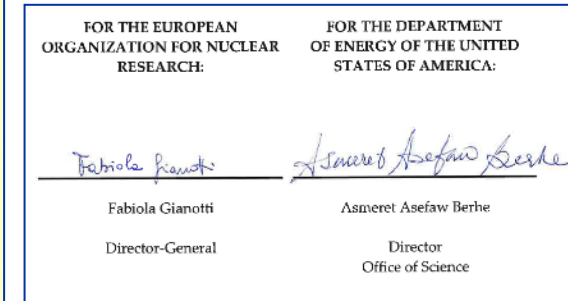
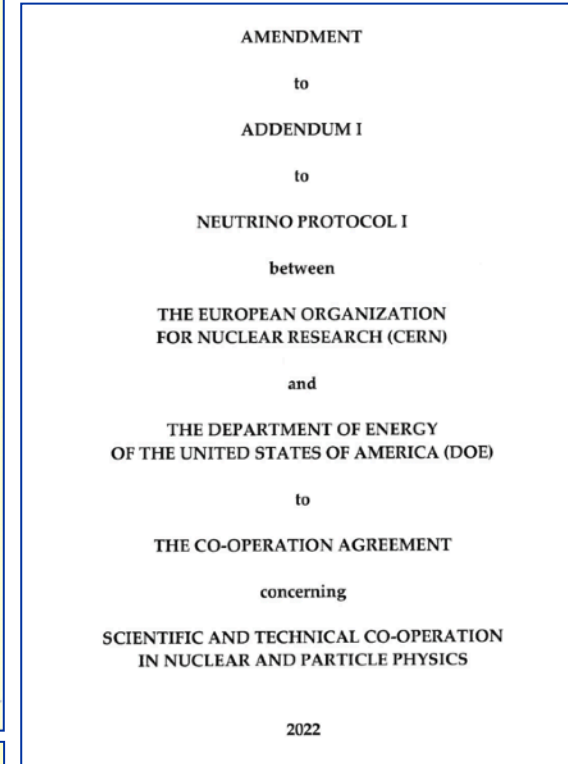
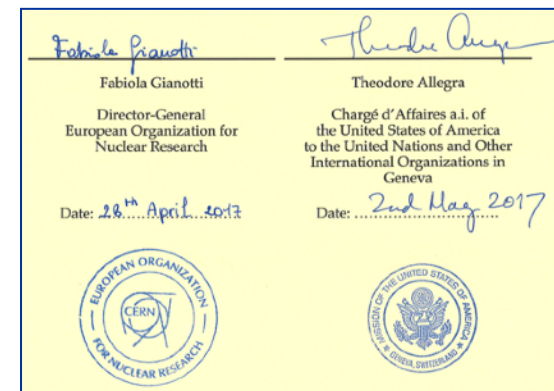
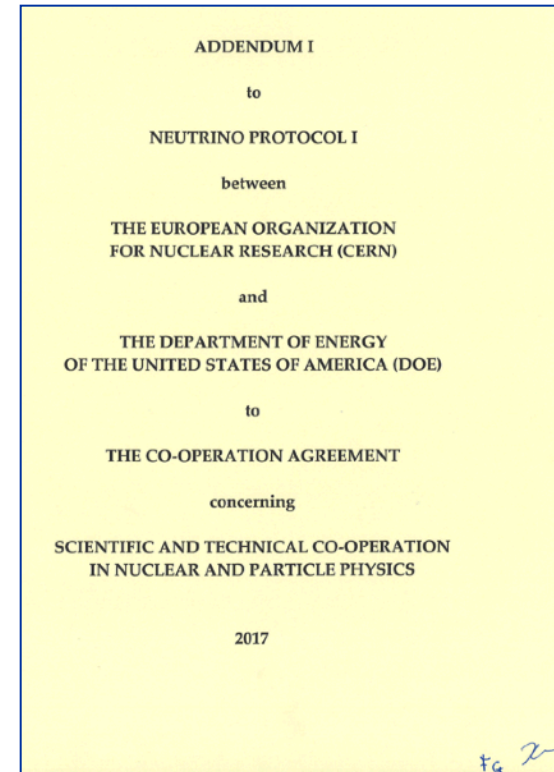
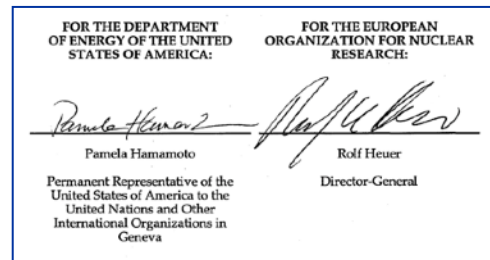
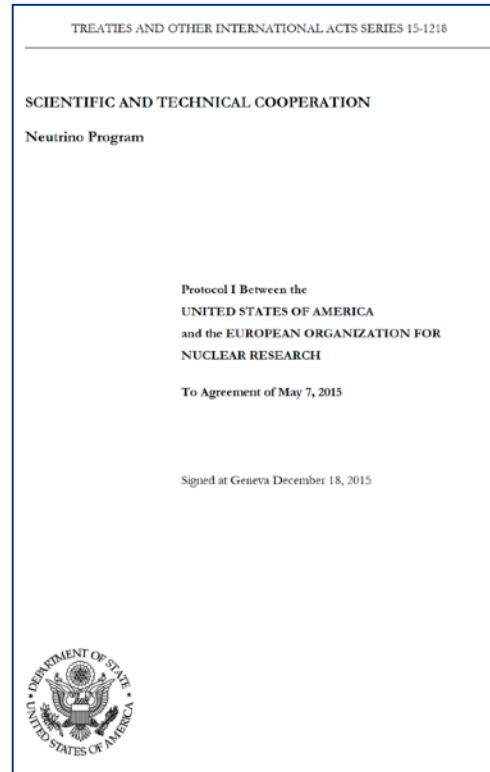


Proton PID (based on chi2 fit to proton dE/dx)

CERN-DOE Neutrino Protocol

- Neutrino Protocol signed in Dec 2015 lays the foundations of the cooperation between CERN and US Department of Energy
- Addendum I (Apr 2017) specifies in-kind contribution of CERN to the LBNF infrastructure: first cryostat
- Amendment (Sep 2022) includes construction of the 2nd cryostat as in-kind contribution

➔ *For LBNF/DUNE, CERN contributes not only to the detector, but also to the infrastructure (cryostats). **This is the first time in CERN's history***



CERN contribution to LBNF infrastructure

- Cryostats construction well underway (on schedule):
 - ✦ Warm structure material for Cryostat #1 delivered and manufacture of the structure components in production
 - ✦ Warm structure Material for cryostat #2 in production (expected completion and delivery for manufacture: end May)

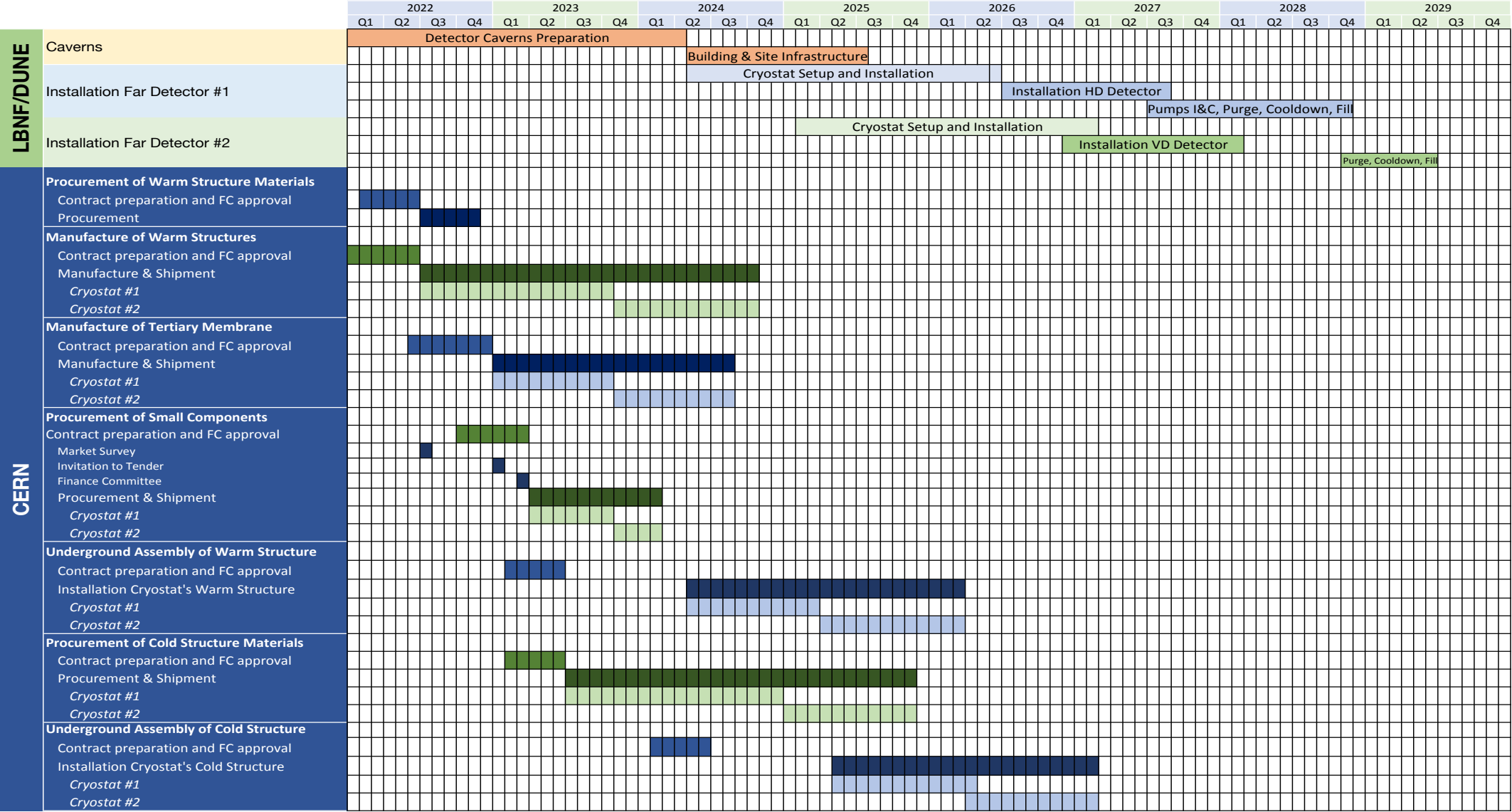
PROCUREMENT MILESTONES	Market survey	Invitation to tender	Finance committee approval
Procurement of warm structure materials	FEB 2022 ^(*)	APR 2022 ^(*)	JUN 2022 ^(*)
Manufacture of warm structure components	JAN 2022 ^(*)	MAR 2022 ^(*)	JUN 2022 ^(*)
Manufacture of warm structure membrane	MAY 2022 ^(*)	SEP 2022 ^(*)	DEC 2022 ^(*)
Procurement of small components	APR 2023	JUN 2023	OCT 2023
Underground assembly of the warm structure	APR 2023	JUN 2023	OCT 2023
Transport warm structure	APR 2023	JUN 2023	OCT 2023
Procurement of cold structure materials	N/A ^(*)	SEP 2023	DEC 2023
Underground assembly of the cold structure	FEB 2024	APR 2024	JUN 2024

(*) On time according to project schedule

(*) Proprietary technology licensed firms



CERN contribution to LBNF infrastructure



European Strategy Update (2020)

- CDS Doc. [CERN-ESU-015](#)
 - Major developments from 2013 Strategy:
 - Recommendation 1.B:
 - ✦ The existence of non-zero neutrino masses is a compelling sign of new physics. The worldwide neutrino physics programme explores the full scope of the rich neutrino sector and commands strong support in Europe.
 - ✦ Within that programme, the Neutrino Platform was established by CERN in response to the recommendation in the 2013 Strategy and has successfully acted as a hub for European neutrino research at accelerator-based projects outside Europe.
 - ✦ **Europe, and CERN through the Neutrino Platform, should continue to support long baseline experiments in Japan and the United States.**
 - ✦ **In particular, they should continue to collaborate with the United States and other international partners towards the successful implementation of the Long-Baseline Neutrino Facility (LBNF) and the Deep Underground Neutrino Experiment (DUNE).**
- ➔ *The 2020 update sets a clear priority on the collaboration to successfully complete the long baseline US program*

European Strategy Update (2020)

- **General considerations for the 2020 update:**
- Recommendation 2.B:
 - ✦ **The European organisational model centred on close collaboration between CERN and the national institutes, laboratories and universities in its Member and Associate Member States is essential to the enduring success of the field.**
 - ✦ This has proven highly effective in harnessing the collective resources and expertise of the particle, astroparticle and nuclear physics communities, and of many interdisciplinary research fields.
 - ✦ Another manifestation of the success of this model is the collaboration with non-Member States and their substantial contribution.
 - ✦ **The particle physics community must further strengthen the unique ecosystem of research centres in Europe.**
 - ✦ **In particular, cooperative programmes between CERN and these research centres should be expanded and sustained with adequate resources in order to address the objectives set out in the Strategy update.**

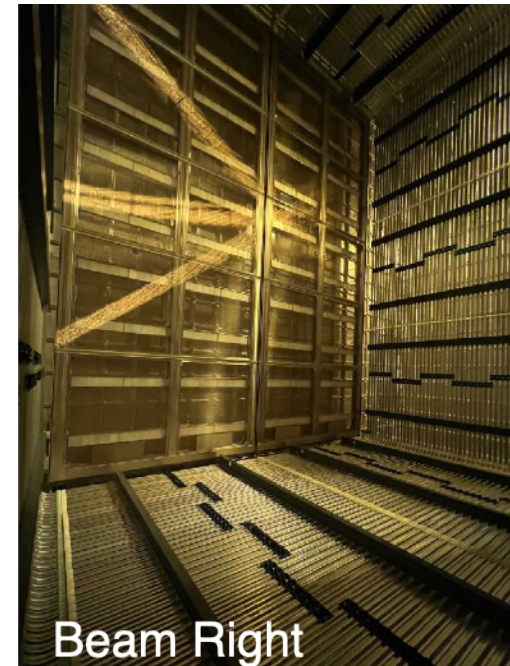
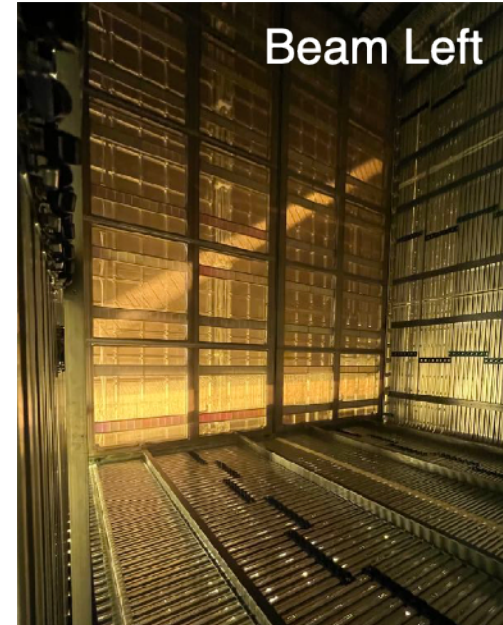
Neutrino Platform today

- Preparing for the beam-tests of both detectors
 - ✦ HD ProtoDUNE in NP04 ready since end-2022
 - ✦ VD ProtoDUNE Module-0 being installed in NP02 (mech. integration completion Apr/May)
- Main uncertainty remains the availability of LAr at an affordable price and for a long time
 - ➡ Targeting 2023-Q4 for LAr filling for beam test in 2024



HD-ProtoDUNE @ NP04

- 4 APAs now in NP04 cryostat
 - ✦ All APA tested in cryogenic conditions prior installation in NP04 cryostat
- APA1 and APA2 (beam right) installed and connected in cryostat by mid October 2022
- PDs and APAs successfully integrated in the DAQ
- Beam right drift closed on November 11th 2022
- Beam plug successfully installed at the beginning of November
- APA3 and APA4 (beam left) installed and connected in cryostat by mid Nov 2022
- Successful integration in the DAQ followed
- Beam left drift closed on the November 22nd 2022
- Close of TCO in Summer 2023
- Fill before end of the year.



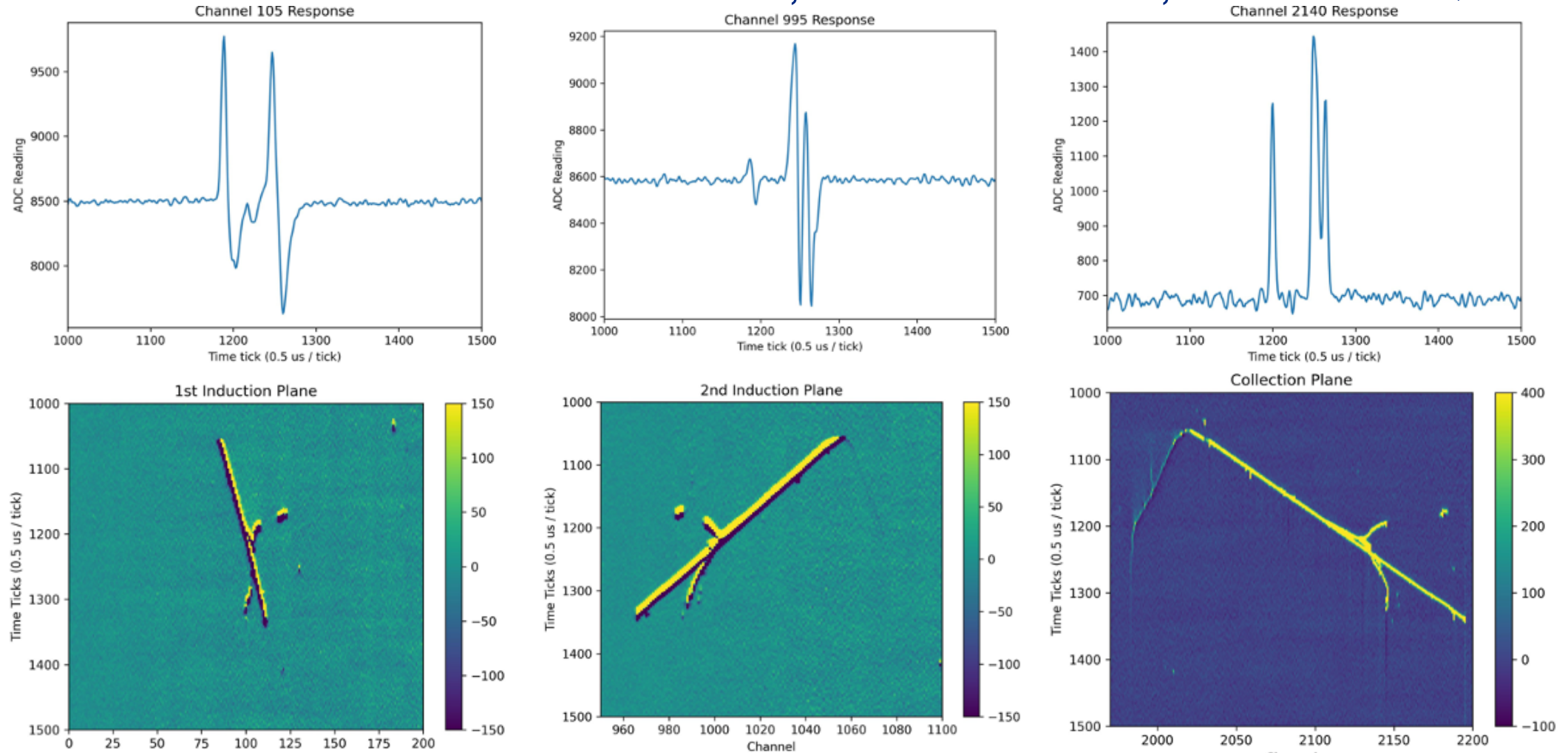
VD-ProtoDUNE @ NP02

- Module-0 Vertical Drift:
 - ♦ 4 DUNE-like CRPs
 - ♦ Half drift volume
- All the 4 CRPs tested in cold box.
- Top two CRPs installed in Jan 2023
- TPC field structures being produced. First modules installed in March.
- Photo-Detector (PD) modules operated on HV tested in cold box and tested in a dedicated setup.
- Cathode with embedded PD modules installed between Feb and Mar 2023
- Bottom CRPs to be installed next
 - ♦ First bottom CRP tested successfully in cold box and ready for installation
- Filling planned after NP04 operation in 2024



VD-ProtoDUNE @ NP02

- Sample track from a cosmic muon recoded during CRP4's cold box test.
- Test of the full nominal chain: CRP bias, front-electronics, readout/DAQ



Neutrino Platform: a glance to the future

- 2023-2024 will focus on the final tests w/ the two ProtoDUNE detectors to validate the productions through beam tests and extended cosmic runs
 - ◆ 4 APAs (2 top, 2 bottom) in NP04
 - ◆ Module-0 testing in NP02
- The unavailability of the LAr at an affordable price and for an extended period required a rebaseline of the program (initially thought in 2022)
 - ◆ Uncertainties remain
 - ◆ Closure of the TCO (for NP04) in the summer, purging and filling likely in 2023.Q4
 - ◆ Possible testbeam in 2024.Q1 after the year-end technical stop
 - ◆ Targeting 2024 (and possibly part of 2025) to test the two detectors w/ beams and cosmics
- There are no definitive plans for the longer-term future of the Neutrino Platform: discussions are starting now

Concluding remarks

- The Neutrino Platform has been instrumental to bring to maturity the LAr TPC detector technology for the scale needed in accelerator-based neutrino experiments:
 - ✦ *ProtoDUNE achievements and developments are critical for successful completion of the DUNE Phase-I by the end of this decade*
 - ✦ Historically, a pivotal role for the European neutrino community
- CERN Neutrino Platform remains the only facility available to all the international partners in the neutrino community for further detector R&D:
 - ✦ CERN is open to possible options for the DUNE's Phase-II detectors
 - ✦ Discussions are (will be) starting now (soon)
- A personal message from Fabiola:
 - ✦ *CERN is committed to continuing to work with DOE and Fermilab towards the successful accomplishment of LBNF/DUNE*
 - ✦ *The strong partnership between CERN and US-DOE is crucial for the future of HEP worldwide*
 - ✦ *CERN looks forward to continuing this collaboration in the context of future collider projects*

Thank you

